School of Economics and Management

TECHNICAL UNIVERSITY OF LISBON

Department of Economics

Cândida Ferreira

Public Debt and Economic Growth: a Granger Causality Panel Data Approach

WP 24/2009/DE/UECE

WORKING PAPERS

ISSN Nº 0874-4548

Public Debt and Economic Growth: a Granger Causality Panel Data Approach

Cândida Ferreira

ISEG-UTL

Instituto Superior de Economia e Gestão - Technical University of Lisbon - (ISEG-UTL)

and Unidade de Estudos para a Complexidade e Economia (UECE)

Rua Miguel Lupi, 20, 1249-078 - LISBOA, PORTUGAL

tel: +351 21 392 58 00

fax: +351 21 397 41 53

e-mail :candidaf@iseg.utl.pt

Abstract

This paper analyses the Granger-causality relationship between the growth of the real GDP per capita and the public debt, here represented by the ratio of the current primary surplus/GDP and the ratio of the gross Government debt/GDP.

Using OECD annual data for 20 countries between 1988 and 2001, we adapt the methodology recently applied by Erdil and Yetkiner (2008) and we conclude that there is clear Granger causality and that it is always bi-directional. In addition, our findings point to a heterogeneous behaviour across the different countries.

These results have important policy implications since not only does public debt restrain economic growth, but also real GDP per capita growth influences the evolution of public debt.

JEL classification: C23; C12; H6
Keywords: Granger causality; panel data; public debt and economic growth

Public Debt and Economic Growth: a Granger Causality Panel Data Approach

1. Introduction

The relevance of the public debt to economic growth has become crucial, particularly to those policy-makers who nowadays have to face increasing fiscal imbalances.

In terms of economic theory, it is widely accepted that at moderate levels of public debt, fiscal policy may induce economic growth, with a typical Keynesian behaviour, but at high public debt levels, the expected tax increases will reduce the positive results of public spending, decreasing the investment and consumption expenses, with less employment and lower GDP growth rates.

On the other hand, there is a broad consensus view that lower GDP growth may also be synonymous with less public revenue and sometimes more public expenditure in social security transfers and other subsidies paid by the Government, which can contribute to the increase of public debt.

However, little empirical investigation has been conducted into the link between public debt and economic growth and the obtained results are still rather inconclusive.

Some authors, like Modigliani (1961), Diamond (1965) or Saint-Paul (1992), have suggested that an increase in the public debt will always decrease the growth rate of the economy.

Recently, several theoretical and empirical works analyse the relationship between the external (and not specifically public) debt and economic growth in developing countries.

Patillo et al. (2002 and 2004) conclude that at low levels, total external debt affects economic growth positively, while at high levels, this relationship becomes negative. Presbitero (2005) uses dynamic panel estimations and find a clear negative relationship between external debt and economic growth.

Schclarek (2004) uses a panel including 59 developing and 24 industrialised countries. For the developing countries, he concludes that there is always a negative and significant relationship between total external debt and economic growth, in clear contrast with the results obtained by Patillo et al. (2002 and 2004), while for Schclarek (2004), there is no evidence of a positive relationship between total external debt and growth at low debt levels. In the case of industrial countries, Schclarek (2004) does not find any robust relationship between gross government debt and economic growth, suggesting that for these more developed countries, higher public debt levels are not necessarily associated with lower GDP growth rates.

Perroti (2002) had already concluded that fiscal consolidations are more likely to have non-Keynesian effects in countries with high debt levels. Furthermore, the European Commission (2003) verifies that during the past three decades, only half of the fiscal consolidation episodes in EU countries were followed by an immediate acceleration in economic growth. For some specific countries in the EU (namely the cohesion countries), Mehrotra and Peltonen (2005) find that an improvement in the net lending position of the government, as well as a fall in the level of public debt, would be beneficial for socio-economic development in the medium term.

With this paper, we seek to contribute to the analysis of the Granger-causality relationship between real GDP per capita and public debt.

We follow a panel data approach, adapting the methodology proposed by Hurlin and Vernet (2001) and Hurlin (2004) and recently applied by Erdil and Yetkiner (2008) to analyse the relationship between real per-capita GDP and per-capita health care expenditure.

Our findings point not only to the existence of Granger-causality between GDP per capita and public debt, but also to the bi-directional character of this causality. In addition, we conclude that there is heterogeneity among the OECD countries. They not only face different initial conditions, but each country may also reveal distinct reactions, on the one hand, of economic growth to public debt and, on the other hand, of public debt to economic growth.

The remainder of the paper is organised as follows: we present the methodological framework in the next section. In Section 3, we report the data used and the estimation results. Section 4 raises policy implications and draws some conclusions.

2. The methodological framework

The choice of methodologies to test Granger-causality with a panel data approach is not very wide.

Most works in this field test vector auto-regression coefficient (VAR) panel data models following the methods proposed by Holtz-Eakin et al. (1985, 1988), Weinhold (1996) and Nair-Reichert and Weinhold (2001). These works mainly test cross-sectional linear restrictions on the coefficients of the model, which are supposed to be variable.

Our methodology is an adaptation of the Granger-causality panel data approach with fixed coefficients which was proposed by Hurlin and Vernet (2001) and Hurlin (2004) and recently applied by Erdil and Yetkiner (2008). It relies on the use of F (or Wald) tests to analyse the existence of causality among the variables.

We also follow Konya's (2004) concerns over unit-root tests. Thus, we first test the stationarity of the variables, using the Levin, Lin and Chu (2002) test and, according to the obtained results, we then choose to use the variables either in levels or in first differences.

The use of panel data fixed-effects robust estimates (following Wooldridge, 2002) provides more observations for estimations and reduces the possibility of multi-colinearity among the different variables. Fixed-effects estimates assume common slopes to all the panel units, but different intercepts (or initial conditions) across the panel units.

To test the causality between GDP and the public debt, we first consider the following equations:

$$GDP_{i,t} = \sum_{k=1}^{p} \alpha_k GDP_{i,t-k} + \sum_{k=0}^{p} \beta_k \, pub.debt_{i,t-k} + u_{i,t} \qquad [1]$$

$$pub.debt_{i,t} = \sum_{k=1}^{p} \chi_k \, pub.debt_{i,t-k} + \sum_{k=0}^{p} \delta_k GDP_{i,t-k} + v_{i,t} \qquad [2]$$

Where:

$u_{i,t} = a_{i,t} + \varepsilon_{i,t}$

$v_{i,t} = b_{i,t} + \varpi_{i,t}$

$a_{i,t}$ and $b_{i,t}$ = intercepts

$\varepsilon_{i,t}$ and $\omega_{i,t}$ = residuals which are supposed to be independently and normally distributed with $E(\varepsilon_{i,t}) = 0$; $E(\omega_{i,t}) = 0$ and finite heterogenous variances $E(\varepsilon^2_{i,t}) = \sigma^2_{\varepsilon,t}$; $E(\omega^2_{i,t}) = \sigma^2_{\omega,t}$; $\forall t = 1, \ldots, T$.

i= individual of the panel (i=1,…,N)

t = time period (t=0,...,T)

p = maximum number of considered lags

We will always assume balanced panels and lag orders (K) identical for all cross-units, respecting the condition $T > 5 + 2K$, which is important to guarantee the validity of the proposed tests, even with shot T samples (see Hurlin, 2004).

We use F-tests to test Granger non-causality and we begin by testing the following hypothesis:

For equation [1]:

H_0: $\alpha_k=0$, $\forall k \, \varepsilon \, [1,p]$; $\forall i \, \varepsilon \, [1,N]$ and $\beta_k=0$, $\forall k \, \varepsilon \, [0,p]$; $\forall i \, \varepsilon \, [1,N]$

H_1: $\alpha_k \neq 0$, $\forall k \, \varepsilon \, [1,p]$; $\forall i \, \varepsilon \, [1,N]$ and $\beta_k \neq 0$, $\forall k \, \varepsilon \, [0,p]$; $\forall i \, \varepsilon \, [1,N]$

and for equation [2]:

H_0: $\chi_k=0$, $\forall k \varepsilon [1,p]; \forall i \varepsilon [1,N]$ and $\delta_k=0$, $\forall k \varepsilon [0,p] ; \forall i \varepsilon [1,N]$

H_1: $\chi_k \neq 0$, $\forall k \varepsilon [1,p]; \forall i \varepsilon [1,N]$ and $\delta_k \neq 0$, $\forall k \varepsilon [0,p] ; \forall i \varepsilon [1,N]$

We complement our analysis with a more restricted model, which does not include lags of the dependent variables as explaining variables:

$$GDP_{i,t} = \sum_{k=0}^{p} \phi_k \, pub.debt_{i,t-k} + w_{i,t} \qquad [3]$$

$$pub.debt_{i,t} = \sum_{k=0}^{p} \gamma_k GDP_{i,t-k} + z_{i,t} \qquad [4]$$

Where:

$w_{i,t} = c_{i,t} + \nu_{i,t}$

$z_{i,t} = d_{i,t} + \mu_{i,t}$

$c_{i,t}$ and $d_{i,t}$ = intercepts

$\nu_{i,t}$ and $\mu_{i,t}$ = residuals which are supposed to be independently and normally distributed with $E(\nu_{i,t}) = 0$; $E(\mu_{i,t}) = 0$ and finite heterogenous variances $E(\nu^2_{i,t}) = \sigma^2_{\nu,t}$; $E(\mu^2_{i,t}) = \sigma^2_{\mu,t}$; $\forall t = 1, \ldots, T$.

i= individual of the panel (i=1,…,N)

t = time period (t=0,...,T)

p = number of considered lags

Next, we test causality, establishing the following hypothesis:

For equation [3]:

H_0: $\phi_k=0$, $\forall k \varepsilon [1,p]; \forall i \varepsilon [1,N]$

H_1: $\phi_k \neq 0$, $\forall k \varepsilon [1,p]; \forall i \varepsilon [1,N]$

and for equation [4]:

H_0: γ_k=0, $\forall$k ε [1,p]; $\forall$i ε [1,N]

H_1: $\gamma_k \neq 0$, $\forall$k ε [1,p]; $\forall$i ε [1,N]

In addition, with this more restricted model we analyse the possible heterogeneity between countries through the values of the obtained R-squares. Since we are using a panel data approach (following Wooldridge, 2002), we may compare the obtained values for the overall R-squared, the R-squared "between" and the R-squared "within". The R-squared "between" represents the variations among the different cross-units (here the different countries) or the OLS estimations applied to the time-averaged equation. While the R-squared "within" measures the variation within each cross-unit (each country) during the considered time interval.

3. Data and obtained results

3.1. The used data

In our panel estimations, we use the Economic Outlook of the OECD Statistical Compendium at annual frequencies for the period between 1988 and 2001. For some OCDE countries, there is no available data for all years and/or all the variables used in our estimations, particularly for the construction of the public primary surplus, as explained below. Therefore, we used data for only 20 countries[1] to obtain a balanced panel of 280 observations.

[1] Namely: USA, Japan, Germany, France, Italy, UK, Canada, Austria, Belgium, Denmark, Greece, Iceland, Ireland, Netherlands, Norway, Portugal, Spain, Sweden, Australia and the Republic of South Korea.

The log of the real GDP per capita will measure economic growth, while to represent public debt, we use the following ratios:

1) primary surplus[2]/GDP

2) gross government debt[3]/GDP

We present the main descriptive statistics of the used series in Appendix 1.

3.2. Unit Root Tests

The number of observations in our panel (20 countries x 14 annual observations) does not lend itself to the application of single-unit root tests for time series. Therefore, we opt to use panel-unit root tests, which are more adequate in this case. These tests not only increase the power of unit root tests due to the span of the observations, but also minimise the risks of structural breaks.

Among the available panel-unit root tests, we choose the Levin, Lin and Chu (2002) test, which may be viewed as a pooled Dickey-Fuller test or as an augmented Dickey-Fuller test when lags are included, and the null hypothesis is the existence of non-stationarity. This test is adequate for heterogeneous panels of moderate size with fixed effects and assumes that there is a common unit root process.

This test implements, basically, an ADF regression:

---

[2] With the provided time series in the Economic Outlook of the OECD Statistical Compendium at annual frequencies, we construct the following variables:

- Public primary surplus = public revenue – public expenditure + other public revenues
- Public revenue = direct taxes + indirect taxes + social security transfers received by the Government + transfers received by the Government
- Public expenditure = Government consumption, non-wage + Government consumption, wage + Government investment + transfers paid by the Government
- Transfers paid by the Government = subsidies + social security transfers + other transfers paid by the Government
- Other public revenues = capital transfers received by the Government + consumption of Government fixed capital + income property received by the Government - income property paid by the Government

[3] Now using the provided series directly.

$$\Delta y_{it} = \delta_i y_{it-1} + \sum_{L=1}^{P_i} \theta_{iL} \Delta y_{it-L} + \alpha_{mi} d_{mt} + \varepsilon_{it}$$

Where:

$i=1,\ldots N$ = cross-units of the panel

$t=1,\ldots T$ = time series observations

$L=1,\ldots,P$ = lag orders

d_{mt} = vector of deterministic variables , with α_m= corresponding vector of coefficients for a particular model (m = 1,2,3)

Assuming that $\alpha=1-\rho$ and $\rho_1 = \ldots = \rho_N$, the null hypothesis of the Levin, Lin and Chu (2002) panel-unit root is H0: $\alpha = 0$ and the alternative, H1: $= \alpha < 0$.

The results obtained with the deterministics, constant and trend up to 2 lags are reported in Table 1 and allow us to conclude that the existence of the null hypothesis may always be rejected.

(Table 1 around here)

3.3. Estimations including the lags of the dependent variables

Following the methodology presented in Section 2, we use fixed-effects panel estimates[4] to test Granger causality between GDP per capita and public debt with the model defined by equations [1] and [2] . Taking into account the presented measures for the public debt, we first

[4] The results of the estimations are available from the author on request.

use the ratio public primary surplus/ GDP, in levels, and then the ratio gross Government debt/ GDP, in first differences.

The F- tests presented in Table 2 allow us to reject the defined null hypotheses, accepting, always at 1% level of significance, the causality between the growth of the real GDP per capita and the public debt, which is measured by the ratios primary public surplus/GDP and gross Government debt/GDP. Furthermore, it is clear that this causality is always bi-directional, which is verified by the results of the two types of F-tests: one including all explanatory variables (presented in the 3rd column of Table 2) and the other excluding the lags of the dependent variables (presented in the last column of the same table).

(Table 2 around here)

3.4. Estimations without the lags of the dependent variables

To complement our analysis, we now use the more restricted model, estimating equations [3] and [4] to test causality between the growth of the real GDP per capita and public debt, which, as before, is represented by the ratio public primary surplus/ GDP, in levels, and the ratio gross Government debt/ GDP, in first differences.

We continue to use F-tests to conclude about causality, but now we also consider the results of the different R-squares in order to analyse the heterogeneity between the different OECD countries included in our panel.

The results reported in Table 3 clearly confirm the bi-directional causality between GDP per capita and public debt.

The R-squares presented in the last column of Table 3 are quite low, reflecting the characteristics of the data (a panel constructed with data for 20 countries during a period of 14 years).

Therefore, on one hand, and according to the obtained values for the overall R-squared and the R-squared "between", we may conclude that there are differences in the behaviour of the distinct countries, so that they should not be considered as a homogenous set. On the other hand, looking at the values of the "within" R-squared, we confirm that the equations mainly report the variations within each of the 20 countries during the considered period of 14 years.

(Table 3 around here)

3.5. Robustness analysis

In order to check the robustness of our results, we applied the same methodology using the ratio net lending, Government/GDP as a measure of public debt. In addition, we tested the methodology with the first differences of all the included variables. The obtained results are not very different from those presented in this paper and are available from the author on request.

4. Concluding remarks and policy implications

This paper empirically explores the Granger-causality relationship between economic growth and public debt, adapting a methodology that was recently used by Erdil and Yetkiner (2008).

We confirm the existence of Granger causality between the growth of the real GDP per capita and public debt, here represented by the ratio of the current primary surplus/GDP and the ratio of the gross Government debt/GDP.

Furthermore, there is clear evidence that this causality is always bi-directional.

This result has important policy implications, since not only does public debt restrain economic growth, but also real GDP per-capita growth influences the evolution of public debt.

In addition, our findings point to heterogeneity across the considered OECD countries. These countries not only face different initial conditions, but may also have heterogeneous relations both between public debt and economic growth and between economic growth and public debt.

References

Diamond, P. (1965), "National Debt in a Neoclassical Growth Model", *American Economic Review*, 55 (5), p. 1126-1150.

Erdil, E. and Yetkiner, I.H. (2008), "The Granger-causality between health care expenditure and output: a panel data approach", *Applied Economics*, first published on 23 June 2008.

European Commission (2003), "Public finances in EMU – 2003" *European Economy*, No. 3/2003.

Holtz-Eakin, D., W. Newey and H. Rosen (1985), "Implementing Causality Tests with Panel Data, with an Example from Local Public Finance", *NBER Technical Working Papers*, No. 0048.

Holtz-Eakin, D., W. Newey and H. Rosen (1988), "Estimating Vector Autoregressions with Panel Data", *Econometrica*, 56 (6), p. 1371-1396.

Hurlin (2004), "Testing Granger causality in heterogeneous panel data models with fixed coefficients" *mimeo*, University of Orléans.

Hurlin and Vernet (2001), "Granger causality tests in panel data models with fixed coefficients" *Working Paper Eurisco* 2001-09, Université Paris IX Dauphine.

Kónya, K. (2004), "Unit-Root, Cointegration and Granger Causality Test Results for Export and Growth in OECD Countries", *International Journal of Applied Econometrics and Quantitative Studies*, 1 (2), p. 67-94.

Levin, A, C. Lin and C. Chu (2002), “Unit Root Tests in Panel Data: Asymptotic and Finite Sample Properties”, *Journal of Econometrics*, No.108, p.1-24.

Mehrotra, A. N. and T. A. Peltonen (2005), *Socio-Economic Development and Fiscal Policy – Lessons from the Cohesion Countries for the New Member States*, ECB Working Paper Series, No. 467.

Modigliani, F. (1961), “Long-Run Implications of Alternative Fiscal Policies and the Burden of the National Debt”, *Economic Journ*al, 71 (284), p. 730-755.

Nair-Reichert, U. and D. Weinhold (2001), “Causality tests for cross-country panels: a look at FDI and economic growth in less developed countries”, Oxford Bulletin of Economics and Statistics, 63 (2), p. 153-171.

Patillo, C., D. Romer and D. N. Weil (2002), *External debt and growth*, IMF Working Paper, No. 02/69.

Patillo, C., D. Romer and D. N. Weil (2004), *What are the channels through which external debt affects growth?*, IMF Working Paper, No. 04/15.

Perroti, R. (2002), *Estimating the Effects of Fiscal Policy in OECD Countries*, European Network of Economic Policy Research Institutes, Economics Working Papers, No. 015.

Presbitero, A. (2005), *The Debt-Growth Nexus: A Dynamic Panel Data Estimation, Quaderno di Ricerca*, No. 243, Dipartamento di Economia, Università Politecnica de Marche, Ancona, Italy.

Saint-Paul, G. (1992), “Fiscal policy in an Endogenous Growth Model”, Quartely Journal of Economics, No. 107, p. 1243-1259.

Schclarek, A. (2004), *Debt and Economic Growth in Developing Industrial Countries*, mimeo, available on-line in http://www.nek.lu.se/publications/workpap/Papers/WP05_34.pdf

Weinhold (1996), “Tests de causalité sur donnés de panel: une application à l’étude de la causalité entre l’investissement et la croissance”, *Économie et prévision*, 126, p. 163-175.

Wooldridge, J. (2002) *Econometric Analysis of Cross Section and Panel Data*, The MIT Press

Appendix 1 - Descriptive statistics of the series*

Variable	Mean	Std. Dev.	Min	Max	Observations
Log Real GDP, per capita overall	2.150615	.8905783	.5022885	4.023911	N = 280
between		.9109032	.5623209	3.88983	n = 20
within		.0452437	1.992913	2.348052	T = 14
Ratio (Public Primary Surplus/GDP) overall	-.0292843	.0731284	-.9465867	.1179836	N = 280
between		.0441778	-.1209672	.0717239	n = 20
within		.059051	-.8549038	.0916828	T = 14
Δ Ratio (Gross Government Debt/GDP) overall	-.0055518	.0558991	-.656562	.1721613	N = 260
between		.0169441	-.0576711	.0174049	n = 20
within		.0533939	-.6274874	.1658475	T = 13

*The series were built using OECD annual data as previously described in Section 2 of this paper; n = number of OECD countries; T = number of years between 1988 and 2001.

Table 1 – Panel-unit root tests – Levin-Lin-Chu

Variables	lags	coefficients	t-value	t-star	P>t	N
Log Real GDP, per capita	0	-0.33027	-9.038	-3.67602	0.0001	247
	1	-0.49807	-14.246	-8.19794	0.0000	228
	2	-0.77832	-17.474	-10.53592	0.0000	209
Ratio (Public Primary Surplus/GDP)	0	-0.78199	-12.999	-7.69788	0.0000	247
	1	-0.84965	- 11.462	- 5.02418	0.0000	228
	2	-1.13491	-13.252	-5.87891	0.0000	209
Δ Ratio (Gross Government Debt/GDP)	0	-0.75054	-11.468	-5.39223	0.0000	247
	1	-1.02247	-13.358	-6.01814	0.0000	228
	2	-1.39711	-13.656	-3.18922	0.0007	209

Table 2 – Results for the model including the lags of the dependent variables*

Dependent variable:	**Explanatory variable:**	**F- tests** (all explanatory variables)	**F- tests** (without the lags of the dependent variables)
Log Real GDP, per capita	**Ratio (Public Primary Surplus/GDP)**	F(5, 215) = 917.48 Prob > F = 0.0000	F(3, 215) = 6.26 Prob > F = 0.0004
Ratio (Public Primary Surplus/GDP)	**Log Real GDP, per capita**	F(5, 215) = 18.31 Prob > F = 0.0000	F(3, 215) = 9.94 Prob > F = 0.0000
Log Real GDP, per capita	**Δ Ratio (Gross Government Debt/GDP)**	F(5, 195) = 670.84 Prob > F = 0.0000	F(3, 195) = 4.57 Prob > F = 0.0041
Δ Ratio (Gross Government Debt/GDP)	**Log Real GDP, per capita**	F(5, 195) = 7.59 Prob > F = 0.0000	F(3, 195) = 8.16 Prob > F = 0.0000

* The model defined with the equations [1] and [2], which were presented in Section 2.

Table 3 – Results for the model without the lags of the dependent variables*

Dependent variable:	**Explanatory variable:**	**F- test**	**R- Squares**
Log Real GDP, per capita	**Ratio (Public Primary Surplus/GDP)**	F(3, 217) = 6.78 Prob > F = 0.0002	within = 0.1561 between = 0.0148 overall = 0.0056
Ratio (Public Primary Surplus/GDP)	**Log Real GDP, per capita**	F(3, 217) = 26.40 Prob > F = 0.0000	within = 0.1126 between = 0.0103 overall = 0.0017
Log Real GDP, per capita	**Δ Ratio (Gross Government Debt/GDP)**	F(3, 197) = 33.73 Prob > F = 0.0041	within = 0.3288 between = 0.0141 overall = 0.0008
Δ Ratio (Gross Government Debt/GDP)	**Log Real GDP, per capita**	F(3, 217) = 12.08 Prob > F = 0.0000	within = 0.2137 between = 0.0014 overall = 0.0018

***** The model defined with the equations [3] and [4], which were presented in Section 2.